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FERNANDEZ-LOPEZ S. & MELENDEZ G. 1995. Taphonomic gradients in Middle Jurassic ammonites of the Iberian Range (Spain). [Gradients taphonomiques chez les ammonites du Jurassique Moyen de la Chaîne Ibérique (Espagne)]

### ABSTRACT

Three categories of ammonite fossils have been distinguished in Middle Jurassic of the Iberian Range, according to their state of preservation : reworked or reelaborated elements, resedimented elements and accumulated elements. The relative frequency of reelaborated vs. resedimented ammonites reflects the trends of the hydrodynamic energy in the sedimentary palaeoenvironments, as well as the polarity of the sequences and their discontinuities. Four categories of abrasion surfaces developed on concretionary internal moulds of ammonites are of interest as palaeobathymetric indicators : annular furrows, ellipsoidal facets, roll facets, and truncational facets. The transition from associations constituted by accumulated or resedimented ammonites, as well as from associations of resedimented or reelaborated ammonites with truncational or roll facets, to associations of reelaborated ammonites with ellipsoidal abrasion facets or annular abrasion furrows, is interpreted as a taphonomic cline indicative of shallowing gradients from subtidal to inter- or even supratidal environments.

KEY-WORDS : PALAEONTOLOGY, TAPHONOMY, FOSSILIZATION, BIOSTRATINOMY, SEDIMENTARY SEQUENCES, FACIES, SEDIMENTARY PALAEOENVIRONMENTS, CARBONATE OUTER PLATFORM, PALAEOBATHYMETRY.

### RÉSUMÉ

D'après leur conservation, trois types de fossiles d'ammonites sont distingués dans le Jurassique moyen des Chaînes Ibériques : les réélaborés, les résédimentés et les accumulés. La proportion des réélaborés par rapport aux résédimentés permet de mettre en évidence l'importance de l'hydrodynamisme des paléoenvironnements ainsi que la polarité des séquences sédimentaires et leurs discontinuités. Quatre types de surface d'abrasion des moules internes d'ammonites présentent un intérêt comme indicateurs paléobathymétriques : les sillons annulaires, les facettes ellipsoïdales, les facettes d'arrondissement et les facettes de troncature. On présente ici un exemple de cline taphonomique indiquant une variation paléobathymétrique depuis des environnements subtidaux jusqu'à des environnements inter- ou même supratidaux. Il se traduit par le passage d'associations d'ammonites accumulées ou résédimentées sans trace d'abrasion à des associations d'ammonites réélaborées avec des facettes ellipsoïdales ou des sillons annulaires d'abrasion, par l'intermédiaire d'associations d'ammonites résédimentées ou réélaborées avec des facettes de troncature et d'arrondissement.

MOTS-CLÉS : PALÉONTOLOGIE, TAPHONOMIE, FOSSILISATION, BIOSTRATINOMIE, SÉQUENCES SÉDIMENTAIRES, FACIES, PALEOENVIRONNEMENTS SEDIMENTAIRES, PLATE-FORME EXTERNE CARBONATEE, PALEOBATHYMETRIE.

### INTRODUCTION

Turbulence or hydrodynamic energy of the environment is an important taphonomic factor in outer platforms, decreasing the likelihood of burial and increasing the duration and intensity of biostratinomic processes (Schäfer 1972; Bayer & Seilacher 1985; Brett & Baird 1986; Norris

1986; Speyer & Brett 1988, 1991; Brandt 1989; Davis *et al.* 1989; Martin & Liddell 1989; Einsele *et al.* 1991; Kidwell 1991; Kidwell & Bosence 1991; Seilacher 1992; Fürsich & Oschmann 1993). Positive taphonomic gradients of remobilization and abrasion indicate increasing of environmental turbulence, which is commonly associated with an increase in the degree of oxygenation and a decrease in depth.



Figure 1 - Geographic setting of the Iberian Range within the Iberian Peninsula. *Situation géographique de la Chaîne Iberique dans la Péninsule Ibérique.*

The purpose of this paper is to show some remobilization and abrasion gradients developed on Middle Jurassic ammonites of the Iberian Basin (Fig. 1) and to present a case of an abrasion taphonomic cline in order to show their relevance as palaeobathymetric and palaeoenvironmental indicator.

## REMOBILIZATION TAPHONOMIC GRADIENTS

Taking into account the state of preservation of the ammonites remains (shells and aptychi) and the modifications resulting from remobilization processes, three categories of fossils have been distinguished in Middle Jurassic ammonites of the Iberian Range : reworked or reelaborated elements, resedimented elements and accumulated elements (Fernandez Lopez 1980, 1984, 1991a).

Reworked or reelaborated elements have been exhumed and moved on the sedimentary surface after being buried and before their final burial. Basic criteria to recognize reelaborated ammonites are : the petrographic difference between the filling and the enclosing sedimentary rock ; the presence of a structural discontinuity between the sedimentary filling and the enclosing rock ; the presence of several phases of cementation and sedimentary filling, inverted geopetal filling, disarticulation surfaces along the boundary between

contiguous chambers of the phragmocone or between the phragmocone and the body chamber, fracture surfaces or abrasion surfaces on the internal mould (Pl. 1, figs 1-7), coating by iron-crusts, and traces of bioerosion or encrusting organisms (Fernandez-Lopez 1985a). Reelaborated internal moulds of ammonites usually maintain their original shape without traces of extensive compression by diagenetic compaction.

Both resedimented and accumulated elements are non-reelaborated elements. Resedimented elements have been moved on the sedimentary surface after their accumulation (i.e. settling on the sea-bottom) and before their burial, being transported or not, and have not undergone reelaboration processes. Resedimentation processes, such as rolling or tumbling on the substrate before the burial, usually generate broken shells. During the resedimentation processes, ammonite shells can be preferentially reoriented. Draught filling of the ammonite shells by turbulence currents can also be important, leading eventually to the formation of an internal mould of the whole phragmocone, even if the shell was unbroken. Resedimented elements can then be identified by the continuous lithological and structural transition between the sedimentary filling and the enclosing rock near the fractures (Pl. 1, fig. 8).

Accumulated elements have been settled on the sedimentary surface after their biogenic production and have not undergone resedimentation or reelaboration processes. In the Middle Jurassic of the Iberian Range, accumulated elements are generally complete shells showing no traces of abrasion or preferential orientation. The draught filling is usually insignificant and restricted to the last portion of the body chamber (Pl. 1, fig. 9). Resedimented or accumulated elements of ammonites can be reduced to compressions as a result of syndiagenetic compaction. Accumulation, as a process undergone by the produced elements (Efremov 1950, fig. 27), must be distinguished from some features of the fossil assemblages such as the abundance or the concentration of elements.

Taphonomic distinction between reelaborated and resedimented elements is of utmost importance for the biostratigraphic analysis since it provides an independent test to identify the diachronic character of reelaborated and non-reelaborated elements within an ammonite association, without involving biochronological hypothesis. Reelaborated ammonites are older than those resedimented, and the age of the bed containing a mixed assemblage of this kind is that of the rese-



SEDIMENTARY  
PALAEOENVIRONMENTS

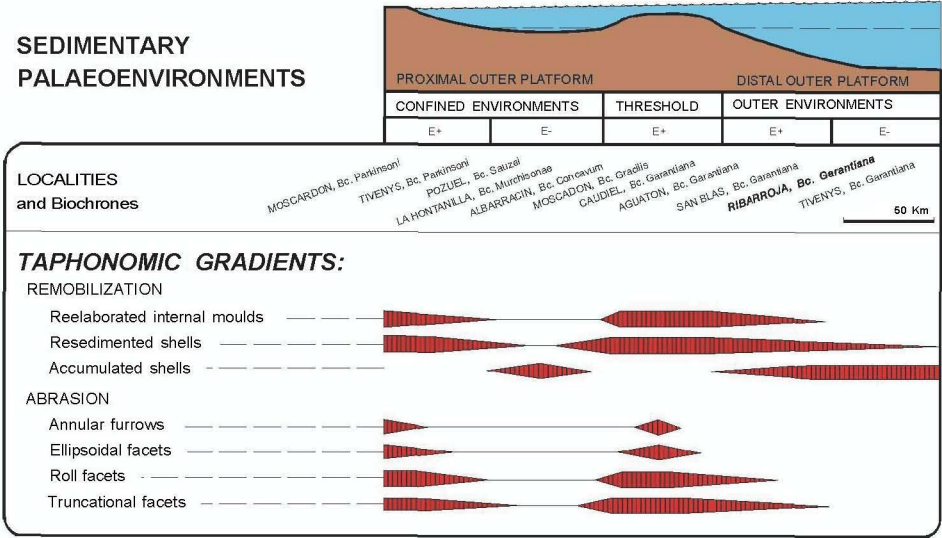


Figure 2 - Remobilization and abrasion taphonomic gradients developed in carbonate outer platform environments as observed on Middle Jurassic ammonites at the Iberian Range. Gradients taphonomiques de remobilisation et d'abrasion développés dans les environnements de plateforme externe et observables sur les ammonites du Jurassique Moyen de la Chaîne Ibérique.

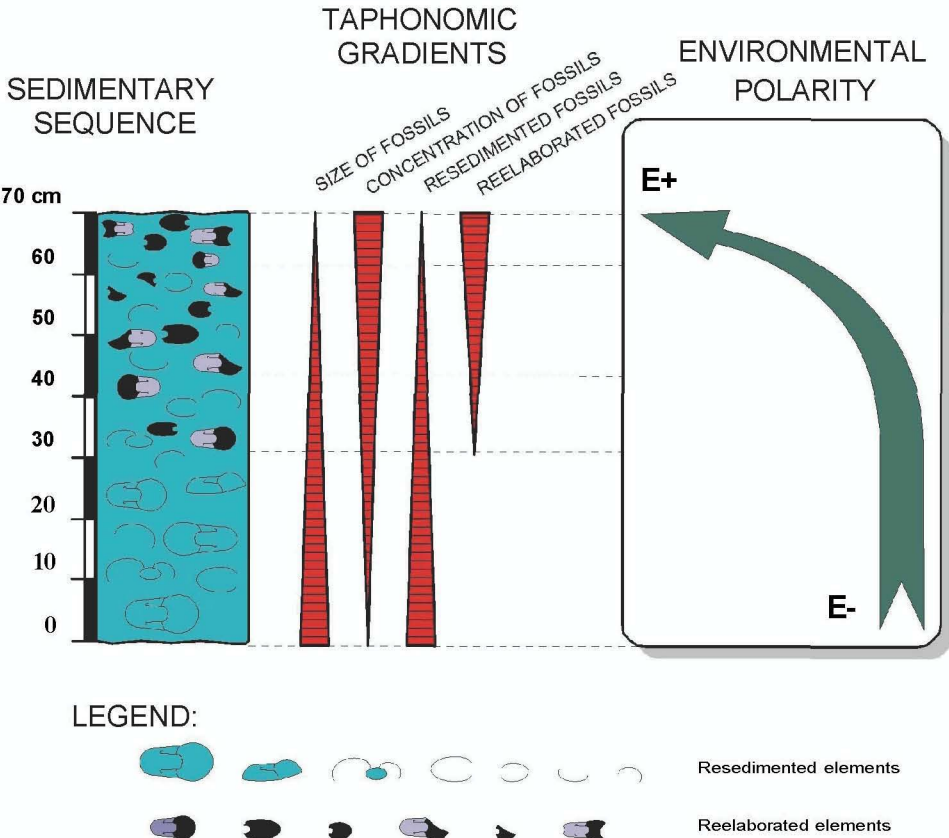


Figure 3 - Taphonomic gradients shown by the successive lower Callovian ammonite associations (Macrocephalus and Gracilis Zones, after Fernandez-Lopez et al. 1978) from Sierra de Albarracin (Teruel, Spain). The sedimentary sequence shows a decrease in the size of fossils and an increase in the concentration of ammonites from the base to the top. Such sequence might be erroneously interpreted as a fining upwards sequence resulting from an increase in depth and a decrease of the hydrodynamic energy of the sedimentary environment. However, the increasing frequency of reelaborated fossils in the upper levels shows that it is in fact a shallowing upwards sequence. E : hydrodynamic energy of the environment. Gradients taphonomiques présentés par les associations successives d'ammonites du Callovien inférieur (Zones à Macrocephalus et Gracilis, d'après Fernandez-Lopez et al. 1978) de la Sierra de Albarracin (Teruel, Espagne). On présente une séquence sédimentaire dans laquelle la taille diminue et la concentration des ammonites augmente du bas vers le haut ; cette séquence pourrait être interprétée, de façon erronée, comme une séquence sraoécroissante, résultant d'une augmentation de la profondeur et d'une diminution de l'énergie hydrodynamique du milieu. Cependant, en tenant compte de l'augmentation de la fréquence des fossiles reelaborés, on doit la considérer comme une séquence de comblement formée dans des conditions d'énergie hydrodynamique

croissante. E : énergie du milieu.

dimented fossils. It should be noted that, according to the meaning proposed for these three taphonomic terms, fossils contained in lithoclasts or

conglomerates (then remanie with respect to the beds containing them, according to Craig & Hallam 1963 and Kidwell et al. 1986) can be accumu-

lated or resedimented with respect to their sedimentary matrix, and not necessarily reelaborated. The terms remanie and reelaborated are not synonymous. On the other hand, reelaborated and resedimented fossils can be autochthonous (since neither resedimentation, nor reelaboration, as taphonomic processes do necessarily mean transport) and accumulated fossils can be allochthonous (if the accumulated elements were submitted to horizontal transport before settling on the bottom surface, e.g. by nekroplanktic drift). The ratio of reelaborated and resedimented vs. accumulated elements reflects the degree of remobilization of any preserved association, whereas the ratio of reelaborated elements vs. resedimented and/or accumulated elements indicates the degree of taphonomic heritage (Fernandez

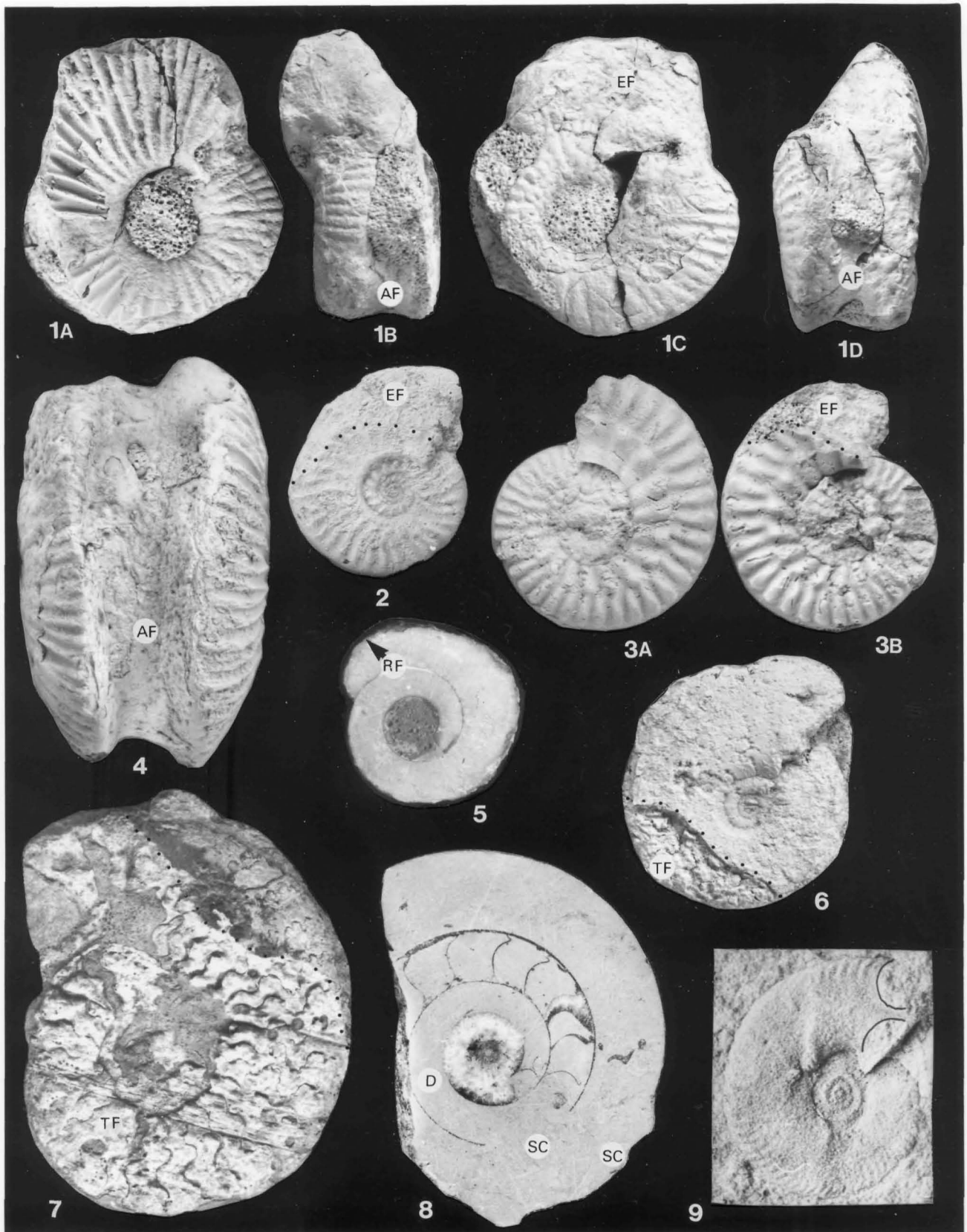
Lopez 1984, 1990; Fernandez-Lopez & Gomez 1990b).

Reelaborated fossils are also useful for sequential analysis since they can supply a great deal of information for palaeogeographic reconstruction and for the interpretation of sedimentary environments (Eshet *et al.* 1988; Traverse 1988; Fernandez-Lopez & Gomez 1990b). The ratio of reelaborated vs. resedimented ammonites permits to identify the trends in the hydrodynamic energy of the sedimentary palaeoenvironments (Fig. 2), as well as the polarity of the sedimentary sequences and their discontinuities. The increasing relative amount of reelaborated vs. resedimented ammonites towards the top of sedimentary sequences constitutes a taphonomic criterion to identify shallowing upwards sequences (Fig. 3).

## PLATE 1

- Fig. 1 - *Macrocephalites* sp., lower Callovian (Moscardón, Teruel, 3M166/4) x 1. Reelaborated internal mould showing an ellipsoidal abrasion facet (EF) on the last third of preserved whorl and an annular abrasion furrow (AF) on the whole venter. *Callovien inférieur (Moscardón, Teruel, 3M166/4) x 1. Moule réélaboré d'ammonite avec une facette ellipsoïdale d'abrasion (EF) dans le dernier tiers de spire conservée et un sillon annulaire d'abrasion (AF) dans la région ventrale.*
- Fig. 2 - *Ludwigella* sp., upper Aalenian (Pinilla del Campo, Soria, 4PV/5) x 1. Reelaborated internal mould showing an ellipsoidal abrasion facet (EF) on the last third of preserved whorl of the phragmocone. *Aalénien supérieur (Pinilla del Campo, Soria, 4PV/5) x 1. Moule réélaboré d'ammonite avec une facette ellipsoïdale d'abrasion (EF) dans le dernier tiers de spire conservée du phragmocône.*
- Fig. 3 - *Chanasia* sp., Callovian (La Olmeda, Cuenca, LM166/1) x 1. Reelaborated internal mould showing an ellipsoidal abrasion facet (EF) on the last third of preserved whorl of the body chamber. *Callovien (La Olmeda, Cuenca, LM166/1) x 1. Moule réélaboré d'ammonite avec une facette ellipsoïdale d'abrasion (EF) dans le dernier tiers de spire conservée de la chambre d'habitation.*
- Fig. 4 - *Macrocephalites* sp., lower Callovian (Moscardón, Teruel, 3M166/2) x 1. Reelaborated internal mould with an annular abrasion furrow (AF) on the whole venter surface of the body chamber. *Callovien inférieur (Moscardón, Teruel, 3M166/2) x 1. Moule réélaboré d'ammonite avec un sillon annulaire d'abrasion (AF) dans la région ventrale de la chambre d'habitation.*
- Fig. 5 - *Hecticoceras* sp., Callovian (Moscardón, Teruel, 3M166/14) x 1. Reelaborated internal mould showing a roll facet (RF) preferentially developed on the most prominent portions. *Callovien (Moscardón, Teruel, 3M166/14) x 1. Moule réélaboré d'ammonite avec une facette d'arrondissement (RF) préférentiellement développée dans la partie plus proéminente.*
- Fig. 6 - *Cypholloceras* sp., lower Aalenian (Olvega, Soria, LV2/1) x 1. Reelaborated internal mould with a truncational facet (TF) on the left side of the phragmocone. *Aalénien inférieur (Olvega, Soria, LV2/1) x 1. Moule réélaboré d'ammonite avec une facette de troncature (TF).*
- Fig. 7 - *Cypholloceras* sp., lower Aalenian (Olvega, Soria, LV2/2) x 1. Reelaborated internal mould with a truncational facet (TF) on the right side of the phragmocone. *Aalénien inférieur (Olvega, Soria, LV2/2) x 1. Moule réélaboré d'ammonite avec une facette de troncature (TF).*
- Fig. 8 - *Bajocisphinctes* sp., upper Bajocian (La Hontanilla, Teruel, EB26/37) x 1. Resedimented shell. The sedimentary filling is in structural continuity (SO) with the matrix through the fragmented portions of the shell wall. Several septa have been dissolved (D) during syndiagenesis. *Bajocien supérieur (La Hontanilla, Teruel, EB26/37) x 1. Coquille resédimentée. Le remplissage sédimentaire et la roche sont en continuité structurale (SC) dans les parties fragmentées de la muraille. Plusieurs cloisons ont été dissoutes (D) pendant la diagenèse précoce.*
- Fig. 9 - *Oecotraustes* sp., lower Bajocian (Moscardón, Teruel, M60U200/1) x 1. Accumulated shell, with complete peristome. Sedimentary filling is restricted to the last portion of the body chamber. The width of the internal mould is reduced to some millimeters as a result of sedimentary compaction during syndiagenesis. *Bajocien inférieur (Moscardón, Teruel, M60U200/1) x 1. Coquille accumulée, avec peristome complet. Le remplissage sédimentaire occupe seulement la dernière partie de la chambre d'habitation. L'épaisseur du moule est réduite à quelques millimètres par compression syndiagénétique.*





Reelaborated ammonites showing abrasion surfaces are quite common at some levels in the Middle Jurassic of the Iberian Range. Some specimens show traces of early dissolution, and infilling of skeletal hollows by sediment during reelaboration episodes (Fernandez-Lopez 1985a: 110, Figs 4-5). They occur in carbonate rocks characterized by the presence of authigenic minerals such as glauconite and ferruginous or phosphatic oolites, associated with indurated surfaces, ranging from firmgrounds to hardgrounds showing a distribution over tens of kilometers and locally displaying mud cracks, karstification surfaces, intraformational breccias and geopetal filling of cavities formed by dissolution. These facies are developed in very shallow subtidal environments within an extended carbonate marine platform locally exposed to subaerial conditions during Aalenian (Fernandez-Lopez 1985b; Fernandez-Lopez *et al.* 1988; Fernandez-Lopez & Gomez 1990a,c), Bajocian (Fernandez-Lopez 1985c; Fernandez-Lopez & Gomez 1991), Bathonian (Wilde 1988, 1990) and Callovian episodes (Gomez 1979; Benke 1981; Mensink & Mertmann 1984; Fernandez-Lopez 1985a,b; Aurell 1990; Aurell & Melendez 1990; Melendez *et al.* 1990; Aurell *et al.* 1992).

Four categories of abrasion surfaces developed on concretionary internal moulds of ammonites are relevant as palaeobathymetric indicators : annu-

Ellipsoidal facets and annular furrows are localized abrasion surfaces developed on reelaborated, concretionary moulds, preferentially on the venter at the last third of the last preserved whorl (Fig. 4). They cut the fabric of the internal

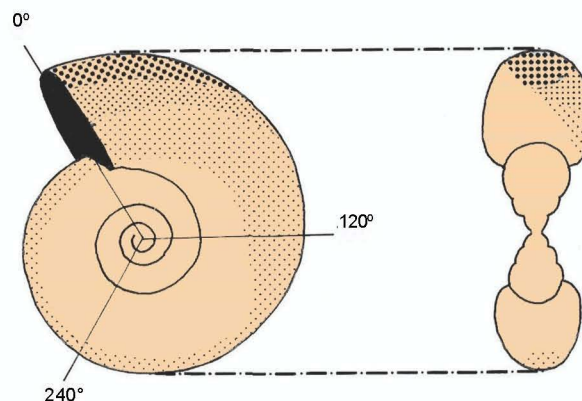


Figure 4 - Sketch of an internal mould of an ammonite, or concretionary steinkern, showing the distribution frequencies of ellipsoidal facets and annular furrows. Areas with denser stipple display higher frequencies. The highest values of abrasion are recorded on the last third, and on the venter surface, of the last preserved whorl. *Schema d'un moule interne d'ammonite montrant la localisation des parties affectées le plus souvent par les surfaces d'abrasion. L'intensité du pointillé indique les parties où les surfaces d'abrasion sont les plus fréquentes. La partie la plus souvent affectée est le dernier tiers de la spire conservée et la région, ventrales du moule.*

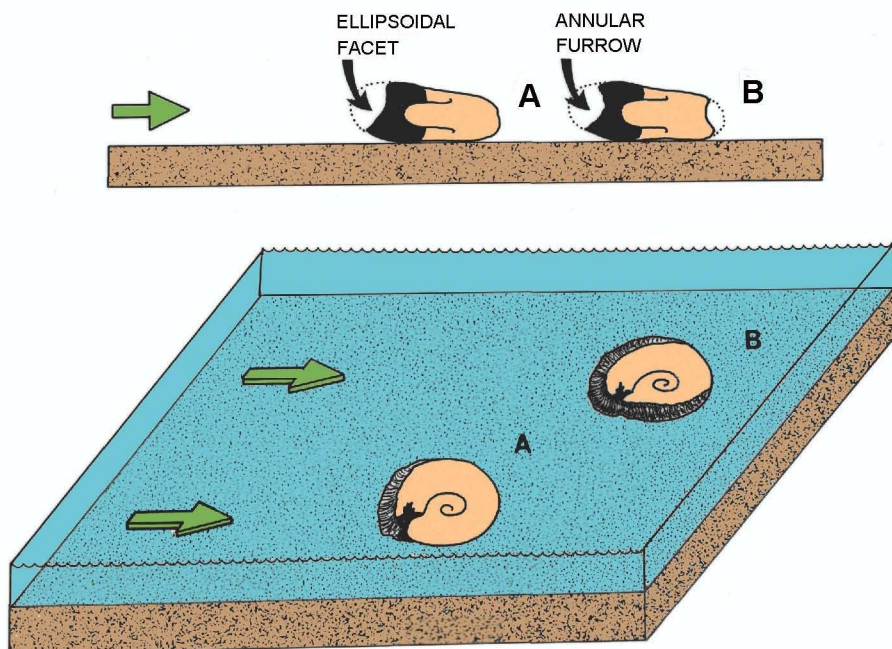


Figure 5 - Development of ellipsoidal abrasion facets on the last third of the last preserved whorl (A) and annular abrasion furrows (B) on reelaborated internal moulds of ammonites submitted to a shallow, directional water current. *Développement des facettes ellipsoïdales d'abrasion sur le dernier tiers de spire conservée (A) et des sillons annulaires d'abrasion (B) sur les moules réélaborés des ammonites.*



moulds, both in complete or incomplete specimens, casting showing a counterpart impression in the enclosing rock. Their variations in shape keep no relation with the distribution of the septa. They are always deeper at the last third of the last preserved whorl and can progress centripetally towards the whorl sides of the last two adjacent whorls. Some specimens showing an ellipsoidal facet on the last third of the last preserved whorl also display a furrow carved along the whole venter surface (Pl. 1, Fig. 1). The edges of these facets and furrows are sharp and irregular, even though the outer surface of the mould may be well preserved and the ornamentation is almost undisturbed on the whorl sides (Pl. 1, Figs. 2-4). Both surfaces may be covered by a ferruginous patina or coating. A relationship can be recognized between the shell morphology and the development of abrasion surfaces, these abrasion surfaces being restricted to discoidal moulds, frequently platycones, more rarely oxycones and never globular spheerocones, ranging from 20 mm to 250 mm diameter. They usually maintain their shape without evidence of extensive compression by diagenetic compaction. As far as the shape of the whorl section is concerned, ellipsoidal facets have only been observed on concretionary internal moulds showing a ratio of whorl thickness to diameter ranging from 0.20 to 0.60. Annular furrows are less common than ellipsoidal facets and they are almost restricted to internal moulds showing a narrower ratio of thickness to diameter, from 0.35 to 0.60.

The origin of annular abrasion furrows and ellipsoidal abrasion facets is explained by the action of directional, non oscillatory, currents in extremely shallow bathymetric conditions, intertidal environments being the most favorable (Fig. 5). Both types of abrasion surfaces develop on free-rotating internal moulds, subjected to directional water currents. Once exhumed and free of matrix, and settled on an uniform and consolidated substratum, the reelaborated, concretionary internal moulds should be able to rotate and reorient. Reelaborated moulds having the center of gravity far apart from the geometric center and localized in the last third of the last whorl, will tend to reorient the last portion of the outer whorl upstream, this portion hence being differentially abraded. An ellipsoidal facet would be first developed, and then the worn area would progress along the venter to carve a whole annular furrow. The water layer should be similar in thickness to the concretionary mould, so the ornamentation is preserved on the upper side of the mould (Fernandez Lopez & Melendez 1994).

The fact that the ornamentation displayed on the whorl sides of the reelaborated moulds, and the angular shape and the sharp edges of facets and furrows, can be used as criteria to exclude a long transport of the concretionary internal moulds before their final burial. Internal moulds with ellipsoidal facets or annular furrows with rounded edges and a higher degree of sphericity indicate later regimes of higher turbulence rather than a long transport.

If the turbulence was produced by wave (oscillatory) action, or by the action of directional currents involving rolling and tumbling of reelaborated internal moulds on the substratum, abrasion would begin at their most prominent portions and the degree of rounding and sphericity would increase instead of decrease. In these conditions, free rolling of reelaborated moulds on the depositional surface would lead to the development of roll facets (Pl. 1, fig. 5).

Elements embedded in a firm or hard sediment being eroded, will develop a truncational facet as they are carved downwards from the top (cf. Seilacher 1971; Seyfried 1981; Melendez *et al.* 1983; Mensink & Mertmann 1984; Fernandez-Lopez 1985a). In these cases, the position of the facets depends on the orientation and the inclination of the partly exposed elements. Under the action of directional (non-oscillatory) currents, in shallow subtidal conditions, reelaborated moulds would tend to be eroded on one side, not on the ventral surface, and to develop truncational facets. The abrasion facets would not be preferentially developed on the last third of the last preserved whorl, ornamentation on the whorl sides would be worn away, the edges of the facets would be less sharp, and the development of annular furrows would be very unlikely (Pl. 1, figs 6-7).

Ammonite moulds showing such abrasion surfaces become a tool in sedimentological and taphonomical analysis within marine carbonate platform sequences since they may constitute the only record of geologic episodes of which no stratigraphic record is preserved.

## A TAPHONOMIC CLINE IN AMMONITES

Geographic variation in the preserved elements resulting from taphonomic alteration, *i.e.* the taphonomic gradients, is not necessarily an effect of palaeoenvironmental transition. A particular taphonomic gradient (e.g. an increase in the degree of fragmentation of the bioclasts) can result from



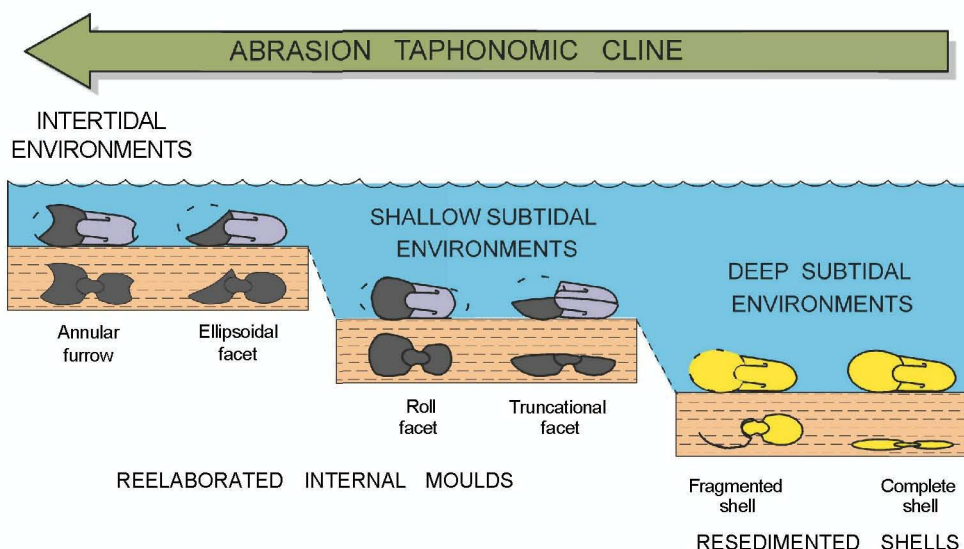


Figure 6 - Abrasion taphonomic cline observed in Middle Jurassic ammonites of the Iberian Basin. Annular furrows and ellipsoidal facets carved on the internal moulds of ammonites are formed by the action of directional currents under extremely shallow conditions, intertidal environments being the most favorable. In a shallow subtidal environment, under the action of a wave (oscillatory) currents, concretionary moulds would tend to overturn and develop roll facets. Under the action of bottom currents, internal moulds of ammonites would tend to be eroded on one side and to develop truncational facets. In a deeper subtidal environment, under a low turbulence regime, reelaboration processes would be unlikely and the most common elements to be found would be either resedimented or accumulated shells, showing no trace of abrasion. Sedimentary filling in such elements is usually restricted to the last portions of the body chamber, and they appear most normally compressed, their width reduced to some millimeters as a result of syndiagenetic compaction. The transition from an association of accumulated or resedimented ammonites, through an association of resedimented or reelaborated ammonites with truncational or roll facets, to one containing reelaborated ammonites with ellipsoidal abrasion facets or annular abrasion furrows, is a taphonomic cline indicative of shallowing gradients from subtidal to inter- or even supratidal environments. *Cline taphonomique par abrasion développé dans les environnements de plateforme externe sur les ammonites du Jurassique Moyen de la Chaîne Ibérique. Les sédiments d'environnements subtidaux de basse énergie contiennent des coquilles accumulées ou resédimentées, sans traces d'abrasion, leur chambre d'habitation n'est remplie que partiellement de sédiments et leur épaisseur est réduite à quelques millimètres par compression syndiagénétique. Vers les aires d'environnements plus turbulentes et moins profondes, voire inter ou supratidaux, les éléments accumulés disparaissent et les moules concrétionnels réélaborés sont de plus en plus fréquents ; ces moules ne présentent pas de traces de compression syndiagénétique et ils ont pu acquérir diverses surfaces d'abrasion (des facettes de troncature ou d'arrondissement jusqu'aux facettes ellipsoïdales dans le dernier tiers de spire conservée et sillons annulaires) en raison des conditions bathymétriques auxquelles ils ont été soumis.*

geographic variations in composition, structure or behaviour of preserved elements. The term cline has been used in geology to denote a gradational series of variant forms (e. g. morphologic or physiologic variations) within a group of closely related (usually conspecific) organisms, generally developing as a result of environmental, geographic, chronological, or stratigraphic transition (Bates & Jackson 1987). Similarly, in order to understand palaeoenvironmental gradients, it is useful to take into account taphonomic clines (Fernandez Lopez 1993). A taphonomic cline is a spatial variation shown by the elements of the same taphonomic group or phyletically related taphonomic groups, developing as a result of environmental transition.

A taphonomic cline can be inferred from the variation observed in the state of preservation of ammonites on the outer platform carbonate rocks in the Iberian Range (Fig. 6). This abrasion taphonomic cline would be represented by the spa-

tial variations displayed by ammonite assemblages, from resedimented shells to reelaborated internal moulds showing, successively, truncational or roll facets, ellipsoidal facets and, eventually, annular furrows. Such taphonomic concept is a relevant criterion in sequence stratigraphic analysis and in palaeogeographical reconstructions (Fig. 7).

## CONCLUSIONS

The ratio of reelaborated vs. resedimented ammonites towards the top of sedimentary sequences is a taphonomic criterion to identify the trend of the sedimentary sequences and the presence of stratigraphic discontinuities.

The transition from an association of accumulated or resedimented ammonites, through an association of reelaborated ammonites displaying truncational or roll facets, to one containing reelaborated ammonites with ellipsoidal abrasion fa-



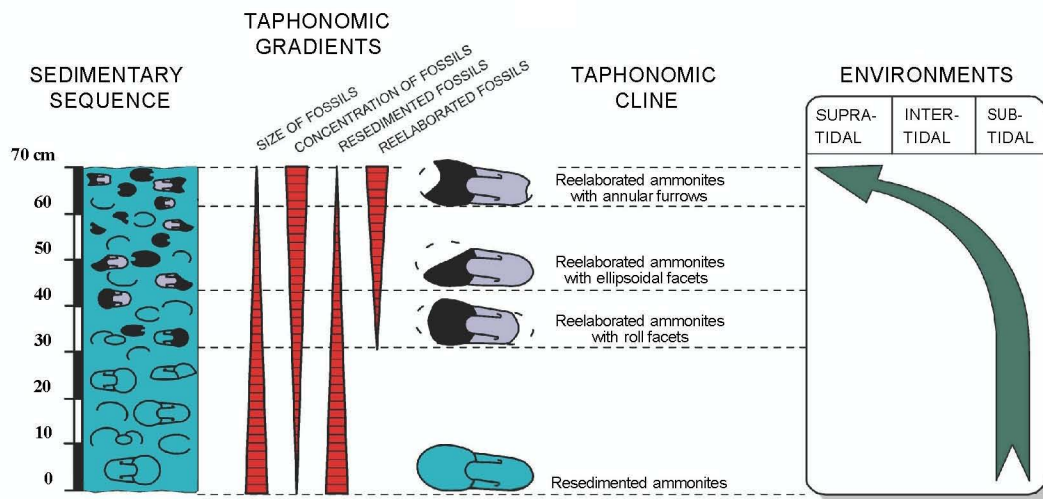


Figure 7 - A case of the application of taphonomic clines in sequence stratigraphy and in palaeogeographic analysis. Taking into account the increase of the amount of reelaborated fossils as well as the presence of fossils showing ellipsoidal facets and annular furrows at the upper levels, the sedimentary sequence presented in figure 3 is interpreted as a shallowing upwards sequence reflecting the passage from shallow subtidal towards inter to supratidal environments. It should be noted that the decreasing size gradient of the fossils does not correlate with the palaeoenvironmental change, the size being related to the specific weight of the preserved elements, whilst the abrasion taphonomic cline clearly expresses the environmental polarity. *Exemple de l'application des clines taphonomiques en stratigraphie séquentielle et dans les analyses paléogéographiques. En tenant compte de l'augmentation de la fréquence des fossiles réélaborés, ainsi que de la présence d'exemplaires avec facettes ellipsoïdales et sillons annulaires dans les niveaux supérieurs, la séquence sédimentaire montrée dans la figure 3 doit être interprétée comme une séquence formée dans des conditions d'énergie hydrodynamique croissante, avec passage d'environnements subtidaux peu profonds jusqu'à des environnements inter et supratidaux. On remarquera que le gradient de taille n'est pas significatif du changement paléoenvironnemental, la taille étant liée au poids spécifique des éléments conservés, tandis que le cline taphonomique par abrasion exprime bien la polarité environnementale.*

cets or annular abrasion furrows, is interpreted as a taphonomic cline indicative of a shallowing gradient from subtidal to inter- or even supratidal environments.

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